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STONE AGE AND THE WORLD OF PRIMITIVE MINING

The role of the primitive mining in providing civilization advancement of the Stone Age communities is shown. The ways of the first minerals development are explored. The technological techniques and mining tools used by miners of the Neolithic flint extraction mines as well as the methods of clay extraction and usage are analyzed. The formation of the established mining communities and their role in obtaining and sharing professional experience is researched. Attention is drawn to the insufficient considering the factors of primitive mining activity in the developing historical scientific notations about the late Stone Age social development.

Key words: the history of mining; the Stone Age; civilization; mining communities.

Problem formulation and its research. Mining arose in the ancient times of the primitive communities' life and initiated the development of technical activity primarily consisting of stone searching, carving and using. More than 99% of the way passed by humans is connected to the Stone Age, the idea of which was formed on the basis of archeological artifacts (mostly presented by the stone tools). Since there was no writing at the ancient times, the social thought of the later historic periods left almost no narratives of that epoch. Late Middle Ages was the time when stone wares, many of which were found in the early excavations by the miners, began to be systematically collected and analyzed. Much deeper understanding of the ancient tools origin and purpose began at the time of the Great Geographical Discoveries (XV-XVII centuries) when Europeans exploring the unknown territories of the globe discovered stone tools used by archaic people.

It should be noted that in the I century BC the ancient thinker, philosopher and poet Titus Lucretius Carus in his treatise "On the Nature of Things" made a supposition about stones used as weapons by humans before the metals appeared. In 1734 French antiquarian N. Moudell floated a sensational idea about existing in the ancient time such a period when all the primary tools and weapons were entirely stone made ("the Stone Age"). In 1836 Danish archeologist, curator of the Copenhagen Archeological Museum collection Ch. Thomsen presented and theoretically proved the famous three-age system (stone, copper, iron)¹. He was the first to place the museum pieces according to cultural and chronological scheme of the tree epochs, which just in 40 years time became dominant in the historical science [1]. In the 60-s of the XIX century English scientist J. Lubbock divided the Stone Age into

smaller periods which were Paleolithic and Neolithic, Mesolithic was latter separated from Paleolithic.

It should be specified that periodization of historical epochs was based on the ancient mining products, which in turn clarifies their all-encompassing influence on humanity civilization development beginning from the earliest times [2]. The role of mining though is generally still out of researchers' sight.

The purpose of the article is to analyze the hypothesis about basic importance of the first minerals extraction activity for providing early human material culture and continuity of mining experience in the process of new resources development (including first metals) in terms of the united mining community [12].

Research and results.

Evolution of the "Homo habilis" and the first fossils.

According to the data of modern archeological and immunological research first "Homo habilis" appeared 2,5-3 million years ago in the central and eastern regions of the African continent. Scientists named them with a Latin term *Homo habilis* (meaning "handy man"). These ancient people could break into pieces and sharpen stones to use them as tools for working or hunting. Split apart and roughly worked stone (so called "hammer-stone") was founded at the same place as the remains of *Homo habilis*. The oldest of the stone tools founded aged 2.5 million years were discovered by archeologists in Gona (Ethiopia).

Around 1,8 million years ago there appeared another spice of Hominidae, those were *Homo erectus* (meaning "upright man"). *Homo erectus* are considered to appear in the Eastern Africa in the epoch of the Middle Pleistocene, and to inhabit Eurasia though the Near East as far as to China. Stone tools of a new type which were double-handed stone axes (flat worked sharply-edged stones) and hammer stones which were tools used for other stones splitting, were founded next to these people remains. According to the "father" of cybernetics N. Wiener, this fact can be considered as a bench mark in the history of engineering as far as "every tool has its basis and originates

¹ Relative dividing of human history into stone, copper and iron epochs was first made in I century BC by ancient China scientist and writer Jun Kung. Unfortunately, these ideas remained little-known to the general public, including a scientific one.

from those tools which were used to make it" [3]. *Homo erectus* was aware of fire using methods and its prolonged baking up, enabling considerable enlargement of a human being climatic dispersal area leading to food heating as a cultural phenomenon.

Homo sapiens which is a human being of a modern appearance originates on the African continent around 130 thousand years ago (much later at the territory of the Europe - 40-50 thousand years ago), already obtaining a significant set of stone tools and some experience in searching, extracting and working of stones. Dominant position among stone materials belonged to chalcedony due to its wide spreading and its split edges property to be sharp and cutting. It was used to make stone axes, haches, scrapers, knives and pikes. Along with chalcedony, obsidian (obsidian) was mined which was used for making the most quality weapons and hunting gear; sandstone, limestone, quartzrock (used to make hummer-stones, hummers, pounders, mortars etc.), jasper and axe stone (cutting tools, decorations), pyrites (used as flintstone), ferric oxide (used as mineral color) etc.

Homo sapiens important achievement was their common ability to control fire by striking a flint at pyrites. The oldest of the pyritic flints founded are dated 40000 BC (Drachloch cave near to St. Gallen). This invention significantly enabled human ability to resist forces of nature and contributed to widening the pyritic ore and other minerals searching area.

The oldest ferric oxide (red hematite) mining was noted in Swaziland (so called Lion cave) and dated 41000 BC. The remains of numerous pit ferric oxide mining were founded on the territory of France and Hungary (aged approximately 35000 BC). This "bloody stone" was mined at the stone epoch for mineral color making which was widely used for conducting magic and ceremonial actions during many thousand years. In particular at the Neolithic period in South-Eastern Europe there was a common burial ceremony where a decedent was covered with a layer of red ochre, which requited considerable amount of ferric oxide mining. Thus mining of the first ores (pyrites, ferric oxide) can be considered to begin 40-45 thousand years ago, and though their usage was not connected to metal making, search for materials different from stone broke new grounds for using the wealth of the earth.

Significant changes in ancient man life are noted at Mesolithic (9000-7000 BC), the beginning of which coincides with the end of the last Ice Age and intense climate warming. The evidence of the changes is a noticeable improvement in stone working; new stone tools appearing which included hoes, mattocks, hacks, headsaws, and wedges as well as tools made with microlites (inserted feather-edged sheets of flint, obsidian or chalcedony as elements of knives, sickles and pikes). Tools making becomes a craft. At places with extensive flint mining the flint processing workshops were sprung up ("stone forge" according to archeological terminology). Flint products were spread over long distances through exchange. People concentration at places with stone mining required such an amount of food which could not be provided by hunting or wild fruit gathering, which in its turn increased motivation to cultivate useful plants and to keep domestic cattle, and it was an additional factor of agricultural and stock raising civilizations generation.

An interesting example of important and the oldest settlement connected to mining is an archeological sight Chatal-Gyuk (Southern Turkey). This proto city sprang up in the middle of VIII century BC near two dead twin-coned volcanoes Karadzhydah and Hasandah. One of the main people's business was obsidian mining (the best Neolithic

"weapons raw material") at the volcano flanks. Archeological excavations uncovered obsidian stock in many dwellings as well as a vast number of quality products made of it (including obsidian mirror). The fact worth attention is that Chatal-Gyuk is the place where some of the oldest ever copper things were founded as well as copper-smelting slags and lead, which can testify the continuity of mining experience in the process of new minerals exploration in terms of miners' united community. Emphasizing the transformational role of mining activity, archeologist J. Mellaart wrote: "Neolithic civilization discovered at Chatal-Gyuk shines like a masterpiece among rather unimpressive group of contemporary agricultural cultures" [4].

Along with Asia Minor, the Southern Caucasus was a famous center of obsidian mining in the Ancient World, the territory of Armenia in particular, which for a few thousand years was a major supplier of this material to the large territories of the Middle East. In historical science there was a special term "obsidian ways" used for indicating obsidian delivery routes to the consumers, which indicates the initial connection of ancient mining to the development of communications and cultural contacts all over the inhabited world.

First mining and flint excavation mines. In 8000-6000 BC when flint stocks on the surface became notably exhausted along with the need in working tools significantly increased, flint excavation from a small depth began. Flint excavation included the following stages: gathering and digging from the surface, open (pit and quarry) and underground work. Every stage changed into another one only after quality flint was depleted by the previous method everywhere (i.e. having depleted reach deposits, stone-hunters didn't investigate the depth, but went to the new territories). Many generations came and went between digging from the surface, open excavating and mining, and transferring experience to the descendants, which formed steady specialized groups of "stone-hunters".

Diverse usage of mining schemes and methods while excavating stone materials could be observed already at Neolithic. At first to excavate flint concretions they made niches which were deepen into tunnels in ravines and steep river banks. This experience was extended to mountains ranges, where due to the rigidity of surrounding rocks the length of tunnels reached tens of meters.

Besides tunnels, mining-type excavation, which origin is connected to the primary pit way of excavation, became rather wide spread. Gradually people understood that in terms of deposits deeper accumulating, entire rock materials excavating at a certain area (quarry, barrow pit) was far more work-consuming than building pit shafts with a fan-shaped horizontal mining works.

Neolithic mining pit shafts measured up 8-10 m depth (15-17 m occasionally), their diameter was from 1m to 4-6 m. They were built at the short distance from one another which provided pit shaft ventilation. At the shaft bottom part there often was operational underreaming, from which along different flint concretions directions mining was driven up to 20m (so-called "petal scheme"). There also could be additional mining stables and passages coming from the main pit shafts, which formed rather complicated labyrinths combining a few pit shafts. The depth of Neolithic mining horizontal excavations was commonly low, from 0,6 to 1,1m. Support pillars made of rock formations were used as constructions for mining roof holding [5 - 7].

Exhausted horizontal excavations were carefully filled with dead rock obtained from nearby mines constructing. Later on pit shafts were also filled with dead rock. It should be noted that filling the caverns in the mining area was not

only connected to the working stability increase but also to special sacred beliefs of archaic miners. "Eco culture" of mineral resources mining tabooed "hurting" the earth surface, requiring its "healing" by filling the caverns made. It was believed that in such a way riches of the earth will be "renewed" enabling miners to find new reach deposits. This approach (Mather-Earth worship) was later expanded to metal ore mining. It is worth attention that the tradition happened to exist for a few thousand years and was held by the miners all over the territory of Eurasia in all mining centers.

Rock ruining was conducted with the help of tools functioning as hammers, stone axes, chisel, hammer-stones, wedges, levers and scrapers. Stone haches and hammers as well as pickaxes made of deer horns were widely spread. To illuminate the mine face people used pitched pine chips. To air the passages, pit shafts were connected between each other. Besides, they used warm air "draft" from the fire kindled underfoot of "ventilation" shaft. It allowed air absorbing through the neighboring pit having outcropping. Pit shifts were equipped with covering and fences to prevent precipitation.

Among the most well-known Neolithic mines preserved to the present days (investigated by scientists, partly turned into museums) here ought to be mentioned the mines in Grimes Graves in the Great Britain, Casa Montero (Spain), Krasnoye Selo (Belarus), Krzemionki in Poland, Spiennes in Belgium and others. Unlike many other ancient ore mines and salt mines which were repeatedly developed at the later times (which led to demolition of many ancient mines), flint mines preserved their primary authenticity.

Flint mines in Krzemionki [8], where a unique archeological museum and reserve is created, is a perfect example of the Late Stone Age mining. Deposits of stripped flints near Krzemionki village (Świętokrzyskie Voivodeship in Western Poland) were exploited for two thousand years beginning from 4000 BC. According to archeological data, the number of pit shafts mines was around 3500. They were located in terms of a parabola-shaped slope mine with 5 km longwise and from 200 to 20 m widthwise (total area equal to approximately 785000 square meters). Total amount of mining works was about 500000 cubic meters. The number of miner at each of the mine was 5-10 people.

Stripped grey flint layers were deposited on two levels, about 3,5m and 8m from the ground. Pit shafts reached up to 9 m in depth. The upper layer was exploited as a widely spread "petal scheme", the lower layer was worked as a "wide stope" forming low (0,8-1m in heightwise) and spacious stables. They were shored up with rock solid blocks and stowing. Rock ruining was made with stone or bone chisels by hitting them with a stone hammer. Excavated flint and rock was transported in baskets, inside of the pit shift it was pulled up in conical basket. More effective technology of the lower layer working and exploitation is an evidence of significant development of experience and empirical knowledge which were shared by miners from generation to generation. Flint annual digging provided producing up to 40000 tools with the area of their distribution reaching 600 km from Krzemionki.

An important center of flint mining was the territory of Vawkavysk Upland in the Western Belarus, in the basin of the Ros River (the Neman River tributary), with the center of which as considered to be Krasnoye Selo [6]. Flint deposits were mined here in the deposits of chalk. There are marks of thousands of mines being developed here from the middle of 4000 BC to the last centuries of 2000 BC. They predominantly were excavating workings of a vertical type located closely to each other and reaching 5-7 m in depth. Traditional filling the workings with the dead

rock is observed here. According to archeologists' research, the population had distinctive professional specialization with miners' clan dominating. Numerous ready-made products as well as semi-finished ones (subproducts) were transported to considerable distances from the mines, in particular to the Baltic coast. The researchers do not exclude connections and experience exchange between Krzemionki and Krasnoye Selo miners.

In Ukraine ancient flint mines were discovered near Horodok, Polovlia and Novomlyn villages (Volynia), Bykivnia village (Ivano-Frankivsk oblast), Studenytsia village (Vinnytsia oblast), Izium town (Kharkiv oblast), Shuroke Village (on the line between Kharkiv and Donetsk oblasts); workings and workshops producing stone products of Neolithic-Bronze ages are also known at a large territory near present-days Kropyvnytskyi [9].

Clay using and mining (prehistoric time - ancient world).

Apart from diverse stones used for tools making and as building materials (sandstone, limestone etc.), clay got wide usage, significantly influencing material culture and people everyday routine. The beginning of their using is traced back to high antiquity. Primitive man could not but draw his attention to wet clay ground property to take shape and keep footprints and different heavy objects. It enabled proceeding to making different things from figurable glue material; at first they were dolls and cult figures, later they were dishes necessary for preserving liquids and cooking food. Fragments (sherds) of pottery are the most frequent findings while excavating archeological artifacts of the Neolithic epoch (beginning from VII thousand years BC) [10].

For a long time pottery was dried in the open air (not burnt). A wish to fasten the process while making pottery resulted in placing products near the fire. Probably the property of clay to develop more strength under fire was discovered in such a way. Gradually pottery kilns (furnaces) were made, which maintained the necessary temperature conditions and evenness of pottery pieces burning.

The Neolithic period was already the time when in the developed pottery centers they used kilns consisting of two tubes, a horizontal and a vertical ones. Such a furnace was built on a high river bank or slopes of the hills or ravines, using the terrain for constructing L-shaped cavity. Horizontal tube served as a furnace, while a vertical one provided natural blowing (it was the place where dried pottery was placed). Sometimes they filled the hole of a vertical tube with small earthenware pieces upon crocks, maintained intensive fire in the furnace for 5-6 hours, afterwards the kiln top was covered up with sand, and the furnace hole was hidden with clay. In such a condition the kiln was left for a few days (temperature in such a device could exceed 1000 °C). Later the furnace was opened, then the kiln top was, and the pottery was taken out of it. Neolithic kilns of this kind were founded by archeologists in Mesopotamia, the North Africa, and the East Europe. This is the moment when ceramics not only met the important practical needs of the society, but for the first time approached to fine arts, the bright example of which is numerous pottery of Trypillia culture (Ukraine).

Understanding the rock property quality changes while fire processing, obtained by the potters in the process of clay burning, was used for thermal changing of other minerals, in particular for glass-making (starting from 4000 BC). It is not impossible that ancient potters-metallurgists could use the experience of pottery kilns building as well as melting pottery glaze crucibles for their attempts of metals liquation. But is ought to be noted that the first accounts of copper liquation (9000-8000 BC) precede

pottery products findings (according to archeologist terminology is a period of Pre-Pottery Neolithic), that is why kilns should not be considered a direct prototype and a necessary condition of first metallurgy furnaces (at least in the oldest centers of copper metallurgy appeared).

Using clay for building purposes had a huge importance for the further mankind development. In the first centers of civilization springing up at the plains near large rivers' basins (territory of Egypt, India, China, Mesopotamia, Ukraine), there was a lack of natural stone, thereat quarry stone required considerable efforts and mining experience, that is why clay was the main building material². The world biggest early agricultural settlements, inhabitants of which mastered large-scale clays working and used mudbrick materials in construction are observed at the territory of Ukraine (Cucuteni-Trypillia culture) [11]. While constructing houses the dwellers clayed the wooden frameworks dried and burned the walls. The area of Trypillia settlements (5000-3000 BC) usually reached a few hectares, and in some cases up to 250-400 hectares, which exceeds the sizes of well-known proto-cities and settlements of that time world (e.g. the size of proto-city of Chatal-Gyuk was equal to 13 hectares, legendary Jericho - to 15 hectares).

Creating clay small-size building elements in a shape of bricks was the mankind remarkable invention. The oldest evidence of using unburnt clay bricks was uncovered in the Central Asia. Such large-size bricks were used at AshiklyHoyuk constructing, which was stockaded with a protective wall (first half of 9000 BC) as well as already mentioned proto-city Chatal-Gyuk, with clay bricks dated at the middle of 7000 BC [6]. Somewhat later people mastered making clay bricks in the Ancient Egypt and Mesopotamia. Probably it was there where in 3000 BC they started making burned bricks which could effectively resist humidity and were durable. The importance of this event was even recorded in the Bible, "They said to each other, "Come, let's make bricks and bake them thoroughly. They used brick instead of stone, and tar (bitumen - *author*) for mortar. Then they said, "Come, let us build ourselves a city, with a tower that reaches to the heavens"³.

They assume that the tower of Babel was called as ziggurat Etemenanki ("temple of the foundation of heaven and earth"), foundations of which are preserved till present days. Huge ziggurat ruins (from the verb "zugaru" - "to build highly") were uncovered on the territory of Iraq and Iran, while the buildings foundation sizes sometimes exceeded 100m in length and 100m in width, the height calculated was 50m. Such temples construction as well as the very Babel city required enormous clay pits, the sizes of which can only be guessed according to the remained "relicts" of a big city [12].

It is of interest, that while constructing the biggest building in the history of mankind, which is the Great Wall of China, total length of with is over 5000 km, the main material used (along with stone flags) was clay and clay bricks. Quantities of clay digging for wall erecting only at times of the emperor Qin Shi Huang (300 BC) exceeded 30 mln cubic meters. Interrelation of giant constructions and mine working providing them with clay is a specific feature of building materials manufacture in the ancient world.

The Neolithic period is the time when pit and open-pit methods of clay excavation were widely spread. It is determined by clay deposits close location to the ground or under thin layers of surface soils, which does not require

great amounts of surface mining. Working tools used included wooden and stone diggers, stone axes, and hacks and shovels later. Methods of clay excavation stayed almost unchanged for a few thousand years.

The oldest miners' work image extant is a 700 BC clay tablet founded at Poseidon sanctuary near Corinth (Greece). It depicts clay pit working: on the left a miner is lifting a hack, being about to break a piece of clay from the passage wall, on the pit floor a boy on his knees is gathering lumps into the basket, on the right a man is passing a heavy pot with clay to a boy; for the sake of the picture completeness there is a amphora filled with water in the center of the composition. It is of interest that many of the clay tablets depicting crafts founded in the Temple of Poseidon depict clay mining (the evidence of these very mining works wide spreading).

Conclusions

Summing the analyses of prehistoric mining development period, it should be noted that development of the first minerals supplied people with stone tools, weapons, "controlled fire" (flintstone), mineral colors, pottery, building materials. Despite considerable disunity of mining, the simplest working tools, archaic miners limited experience and not sufficient informational exchange between the regions, the Late Stone Age period was the time of diverse minerals developing, laying the foundation for their mining and forming first professional mining communities. It enabled human resistance to nature elemental forces, valuable material and intellectual artefacts creation, prepared basis for principally new minerals-metals development and methods of their working methods, invented by the ancient miners' communities [13].

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² Even at the places where construction was mainly stone and wood based, clay was also widely used as a building material.

³ Bible Genesis 11: 3; 4.

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КАМЕННЫЙ ВЕК И МИР ПЕРВОБЫТНОГО ГОРНОГО ДЕЛА

Статья посвящена определению роли первобытного горного дела в обеспечении цивилизационного развития сообществ каменного века. Авторы доказывают базовое значение деятельности по добыче первых полезных ископаемых для обеспечения первоначальной материальной культуры человечества и преемственность горного опыта в процессе освоения новых полезных ископаемых (в т.ч. первых металлов) в рамках единого сообщества горняков. Показано, что освоение первых полезных ископаемых обеспечило человека каменными орудиями труда, оружием, "прирученным огнем" (огнивами), минеральными красками, глиняной посудой, строительными материалами. Несмотря на значительную раздробленность горных промыслов, простейшие орудия труда, ограниченный опыт архаичных горняков и недостаточный информационный обмен между регионами, в период позднего каменного века были освоены различные полезные ископаемые, заложены первоосновы их подземной добычи, сформированы первоначальные профессиональные сообщества горняков. Это позволило человеку противостоять стихийным силам природы, создавать ценности материальной и духовной культуры, подготовило почву для овладения принципиально новыми полезными ископаемыми - металлами и способами их обработки, которые были изобретены первобытными сообществами горняков.

Ключевые слова: история горного дела; каменный век; цивилизация; горные сообщества.

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КАМ'ЯНА ДОБА І СВІТ ПЕРВІСНОГО ГІРНИЦТВА

Стаття присвячена визначенню ролі первісного гірництва в забезпеченні цивілізаційного поступу спільнот кам'яної доби. Автори доводять базове значення діяльності з видобутку перших корисних копалин для забезпечення первісної матеріальної культури людства та спадкоємність гірничого досвіду в процесі освоєння нових корисних копалин (у т.ч. перших металів) у межах єдиної спільноти гірників. Показано, що освоєння перших корисних копалин забезпечило людину кам'яними знаряддями праці, зброєю, "прирученим вогнем" (кресалами), мінеральними фарбами, глиняним посудом, будівельними матеріалами. Не зважаючи на значну роздробленість гірничих промислів, найпростіші знаряддя праці, обмежений досвід архаїчних гірників і недостатній інформаційний обмін між регіонами, у період пізньої кам'яної доби були освоєні різноманітні корисні копалини, закладені першооснови їх підземного видобутку, сформовані первісні професійні спільноти гірників. Це уможливило протистояння людини стихійним силам природи, створення цінностей матеріальної та духовної культури, підготувало підґрунтя для опанування принципово нових корисних копалин - металів і способів їх обробки, винайдених первісними спільнотами гірників.

Ключові слова: історія гірництва; кам'яна доба; цивілізація; гірничі спільноти.